## SALINE SOLUBLE INORGANIC FIBRES

This invention relates to saline soluble inorganic fibres.

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Saline-soluble inorganic fibres have been described in several patent specifications, see for example WO93/15028. Fibres are required to be soluble insaline solution so that inhaled or ingested fibres dissolve rather than providing a source of irritation or otherwise affecting health. WO93/15028 showed that fibres comprising SiO<sub>2</sub>, CaO and MgO and having a silica content of greater than 58% (or greater than 58% plus 0.5 times (wt%MgO - 10) if MgO > 10wt%) had suitable shrinkage characteristics at 800°C and 1000°C to be usable as refractory materials. A further feature of WO93/15028 was the use of the percentage of non-bridging oxygens present to predict the solubility of fibres in physiological saline solution.

Various subsequent applications have described the effect of  $P_2O_5$  and  $B_2O_3$  on Solubility - see for example WO95/29135.  $P_2O_5$  is alleged to have a solubilising effect on such fibres. WO93/22251 refers to use of  $P_2O_5$  and  $P_2$ 

The German government have proposed a fibre classification which turns on a variable K<sub>I</sub> which is defined as:

 $K_I = \Sigma(Na,K,B,Ca,Mg,Ba \text{-oxide}) - 2* Al\text{-oxide}$  (the amounts of the oxides being expressed as weight %)

According to the proposed fibre classification if  $K_I$  is greater than 40 the fibre requires no health warnings. If  $K_I$  lies between 30 and 40 the fibre requires health warnings to be made. If  $K_I$  is less than 30 more serious marking is required (it is labelled as a carcinogen). It is readily apparent that it is difficult to provide a high  $K_I$  fibre ( $K_I$ >40) while still providing a refractory fibre like that of WO93/15028 (SiO<sub>2</sub>>58wt%), there being a very narrow window of compositions to meet.

As a result of investigating fibre compositions that may meet the fibre classification and yet still be refractory enough to meet the standard of WO93/15028 (shrinkage of less than 3.5% at both 800°C and 1000°C) the applicants have found that addition of  $P_2O_5$  to compositions allows a broader range of refractory fibres to be produced than had previously been appreciated.

They have also found that  $B_2O_3$ , previously thought to be extremely detrimental to refractoriness, has a similar, although lesser, effect and that both  $P_2O_5$  and  $B_2O_3$  may be used in the fibres of WO93/15028.

The applicants have found that the refractoriness of the  $P_2O_5$  and  $B_2O_3$  containing fibres of the present invention is dependent on the sum of the amounts of  $SiO_2$  and  $P_2O_5$  (expressed in wt%)

It appears that a further factor that may be important in determining the refractoriness of a fibre is the percentage of non-bridging oxygens. If this percentage is 61.4% or more (calculated on the basis of the amounts of the components SiO<sub>2</sub>, CaO, MgO, P<sub>2</sub>O<sub>5</sub>, and B<sub>2</sub>O<sub>3</sub>) the fibres tend to fail shrinkage tests at 800°C and 1000°C (failure being defined as a shrinkage of 3.5% or more).

The scope of the invention is apparent from the claims in the light of the following description.

The percentage of non-bridging oxygens (%N.B.O.) is calculated by converting the weight percentages of SiO<sub>2</sub>, CaO, MgO, P<sub>2</sub>O<sub>5</sub>, and B<sub>2</sub>O<sub>3</sub> to molar amounts and inserting these amounts into the equation:-

%N.B.O. = 
$$\frac{2*(CaO + MgO + P_2O_5 + B_2O_3)}{(2*SiO_2 + CaO + MgO + 5 \times P_2O_5 + 3 \times B_2O_3)} \times 100$$

The reason the amounts of CaO, MgO, P<sub>2</sub>O<sub>5</sub>, and B<sub>2</sub>O<sub>3</sub> are doubled in the numerator to this equation is that each contributes two non-bridging oxygens. The reason terms are multiplied in the denominator to this equation is to reflect the number of oxygen atoms each molecular formula possesses.

Table I shows the results of a first set of shrinkage and solubility tests on compositions comprising SiO<sub>2</sub>, CaO, MgO, P<sub>2</sub>O<sub>5</sub>, and B<sub>2</sub>O<sub>3</sub> as main

ingredients. In this table the analysed compositions are normalised to 100%. It is clear from these compositions that where the percentage of non-bridging oxygens calculated on the basis of the amounts of the above named components is greater than 61.4% (those fibres lying above line A of Table I) the fibres-fail the shrinkage tests, having shrinkages of greater than 3.5% at either or both of 800°C and 1000°C.

WO93/15028 stressed the importance of alumina content and the fibres lying between lines B and A of Table I show that alumina contents of greater than 1wt% are damaging to the shrinkage properties of fibres.

The applicants have also found that the combined amount of CaO and MgO is important. Those fibres lying between lines C and B have a combined CaO and MgO content of greater than 42wt% and also fail the shrinkage tests.

The fibres below line C have a percentage of non-bridging oxygens less than 61.4%, an alumina content of less than 1wt%, and a combined CaO and MgO content of less than 42wt%. All of these fibres pass the shrinkage tests. These fibres fall within the compositional ranges:-

SiO<sub>2</sub> 52.4 - 57.85wt% CaO 22.2 - 39.4wt% MgO 1.96 - 17.4wt% P<sub>2</sub>O<sub>5</sub> 0.82 - 7.8wt% B<sub>2</sub>O<sub>3</sub> 0 - 1.95wt% Al<sub>2</sub>O<sub>3</sub> <1wt%

The solubility results presented in Table I were obtained by the methods described in WO93/15028 and show a high solubility for all of the fibres produced.

It can be seen that all of the fibres below line C have a  $K_I$  of more than 35 and more than half have a  $K_I$  of more than 40.

Further testing resulted in the data presented in Table II. The data presented are as in table I but an additional column entitled deviation shows the result of looking to the difference between the sum of the SiO<sub>2</sub> and P<sub>2</sub>O<sub>5</sub> contents and the SiO<sub>2</sub> amount predicted to be needed by WO93/15028 for a fibre to be refractory (shrinkage of less than 3.5% at both 800°C and 1000°C. The figure given is found by calculating the sum

 $SiO_2 + P_2O_5 - (58 + (if MgO > 10, 0.5 \times (MgO - 10) else 0))$ 

If this is less than -2.4wt% the fibres fail. The fibres that failed are shown in plain text, those that passed in bold text, and those that were difficult to form in italics.

More than 12.5wt% P<sub>2</sub>O<sub>5</sub> is undesirable as it causes difficulties in making the fibres.

While the above description and the claims refer to  $P_2O_5$ ,  $B_2O_3$ ,  $SiO_2$ , CaO and MgO it will be clear to the person skilled in the art that the pure materials need not be used and that provision of these components in combined form (e.g. provision of  $P_2O_5$  in the form of mixed oxide phosphates) is part of the invention.

Table I

																	4		8		၁												•				
% N.B.O.		68.5%	68.1%	%0.89	%1.99	64.7%	64.3%	64.1%	63.9%	63.7%	63.0%	63.0%	62.6%	62.6%	62.2%	%6.19%	61.4%	\$6.0%	58.4%	\$8.8%	60.3%	\$7.5%	%0.09	\$9.0%	28.0%	28.8%	58.2%	%0.19	55.4%	%8.09	55.7%	58.7%	\$7.7%	54.5%	\$4.0%	\$5.5%	53.3%
	CaO+MgO	44.14	43.47	44.20	44.11	42.37	41.83	41.40	43.94	44.18	41.95	39.23	42.27	42.40	42.59	39.58	. 38.23	36.40	39.70	42.38	42.20	41.36	40.84	40.28	40.25	40.19	40.12	39.60	39.56	39.45	39.08	38.94	38.87	38.42	38.25	38.24	37.09
	Total	328	367	323	355	317	331	362	306	310	338	335	361	356	327	350	320	286	310	292	300	262	361	289	315	327	344	359	292	316	284	327	337	52	312	288	292
	B203																						20			12	12		6		91			25			
y (ppm)	SiO2	171	193	174	200	169	180	161	161	199	161	188	207	200	204	14	152	140	159	206	208	209	194	172	188	187	192	197	175	167	503	17.5	202	18	193	173	175
Solubility (ppm)	MgO	86	115	8	9/	8	95	901	32	29	69	117	72	17	35	166	132	74	69	10	34	11	9	22	13	8	65	104	25	96	33	68	84	33	28	48	46
	CaO	53	\$	55	20	88	\$	65	83	82	78	9	8	88	88	5	36	72	82	76	28	72	87	65	92	62	75	28	83	53	32	63	84	\$	6	67	71
Shrtnkage	800°C 1000°C	40.0	38.8	39.1		19.1	4.77	5.39	43.8		3.92	5.26	30.1	29.7	5.03	29.5	15.5		3.61		35.5	2.04	2.32	2.76	1.79	1.84	1.81	2.14	1.40	3.05	1.93	1.71	1.53	239	8.1	1.16	0.99
Š	800°C	40.0	23.9	46.8	49.1	3.62	3.71	3.63	45.2	42.90	3.24	5.72	2.55	3.38	3.41	23.3	10.9	32.1	3.07	45.9		1.74	1.20	<u>89</u>	1.40	0.97	1.04	1.97	1.07	2.24	1.47	1.31	1.24	1.15	1.22	0.99	0.91
32		4.0	43.0	43.9	4 -	42.3	41.5	41.0	43.6	4.0	41.8	39.4	42.0	42.1	42.5	39.4	38.4	32.6	37.3	42.0	42.0	41.0	42.5	40.2	<del>8</del>	41.1	=	39.3	40.3			38.7	38.2	40.0	38.0	38.2	36.9
	SrO	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05	<0.05	< 0.05	< 0.05	<0.05	< 0.05	< 0.05			< 0.05	<0.05	< 0.05		<u> </u>		<0.05		< 0.05	< 0.05	<0.05
	2072	< 0.05	0.15	< 0.05	< 0.05	< 0.05	0.25	0.21	0.38	< 0.05	0.25	< 0.05	< 0.05	0.10	0.13	0.46	< 0.05	<0.05	<0.05	0.17	< 0.05	<0.05	<0.05	< 0.05	<0.05	<0.05	<0.05	<0.0\$	<0.05	0.58	<0.0>	< 0.05	0.18	<0.05	0.07	<0.05	<0.05
ent)	B203 F203	0.17	0.17	0.17	0.17	0.16	0.15	0.14	0.16	0.15	0.15	0.17	0.15	0.16	0.16	0.14	0.16	1.38	0.26	61.0	0.15	0.21	0.16	0.15	0.15	0.15	0.15	0.1	0.15	0.16	0.14	0.14	0.15	0.15	0.14	0.14	0.13
ght per																		<0.05	<0.05				88.			1.11	1.08	<0.05	0.94		1.06		<0.05	1.95			<0.05
F. Wei	K20	0.05	<0.05	0.03	90.0	0.03	0.05	< 0.05	0.07	0.07	0.03	< 0.05	90.0	90.0	0.10	< 0.05	< 0.05	0.05	0.07	0.12	0.07	0.10	0.01	0.05	0.03	0.07	0.07	0.03	0.08	< 0.05	0.08	90.0	0.03	80.0	90.0	0.03	0.0
ton (XF	Na20	0.30	0.31	0.25	0.42	0.28	0.26	0.30	0.42	0.46	0.45	0.13	0.31	0.31	0.43	0.29	0.15	0.28	0.29	0.39	0.46	0.41	0.30	0.32	0.31	0.32	0.33	0.31	0.30	0.24	0.30	0.22	0.34	0.31	0.43	0.36	0.33
ompost	AJ203	0.25	0.38	0.28	0.26	0.21	0.31	0.33	0.40	0.34	0.30	< 0.05	0.32	0.32	0.31	0.25	< 0.05	2.06	1.38	0.43	0.39	0.45	0.27	0.21	0.25	0.28	0.27	0.31	0.31	0.46	0.27	0.24	0.52	0.38	0.36	0.22	0.29
Chemical Composition (XRF - Weight percent)	SiO2	51.69	50.42	52.54	51.59	54.46	53.85	52.72	51.22	52.23	51.96	\$7.2	53.52	54.14	51.22	52.58	58.18	54.8	56.6	55.09	54.19	55.25	55.63	\$5.65	57.3	56.19	57.13	55.2	57.84	54.25	57.39	~	52.4	57.85	\$6.95	57.32	89
S	P205	3.41	5.10	2.51	.339	2.48	3.31	4.91	3.41	2.57	4.90	3.26	3.36	2.52	5.05	6.70	3.29	4.89	1.62	1.23	2.54	2.22	0.83	3.34	1.68	1.68	98.0	3.98	0.82	4.87	1.67	3.33	7.8	98.0	3.73	3.66	2.67
	MgO	19.18	18.66	19.07	12.27	17.89	17.78	17.17	5.54	5.56	10.11	27.95	11.35	11.35	5.70	16.69	27.85	11.5	11	2.09	5.58	1.96	9.48	10.45	9.81	9.68	9.56	17.4	4.73	16.10	4.73	<u>=</u>		4.75	4.56	9.33	8.69
	CaO	24.95	24.81	25.13	31.83	24.48	24.04	24.22	38.39	38.62	30.93	11.28	30.93	31.05	36 89	12.89	10.37	24.9	28.7	40.29	36.62	39.40	31.36	29.83	30.44	30.51	30.55	22.2	34.82	23.35	_	3	32	33.67	33.69	28.91	28.4
<b>ق</b>	LTP	LTP8	LTP9	LTPI	LTP16	LTP10	LTP 4	LTP 5	LTP17	LTP33	LTP14	LTP13	LTP12	LTP20	L.TP15	LTP 3	1.TP 7	LTP52	LTPS1	1.TP29	LTP31	1.TP30	LTP41	LTP 6	LTP34	LTP43	LTP42	LTP47	LTP38	LTP 2	1.TP39	<u>[</u>	LTP48	LTP40	LTP26	1.TP27	1.TP46

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## TABLE II (Part 1)

COO     MgO     PROOF     SNOT     ALTON     NACO     ROO     BROOF     EACH     NOT     CAD     ALTON     ROO     PROOF     Devision     CAD     MgO     SNOT     ALTON     ALTON     ALTON     ROO     BROOF     CAD     ALTON     <	Soge	L		5	Chemical Composition (XRF	omposit	ion (XR		- Weight percent)	Ħ			3	S	Shrtnkage			Solubility (ppm)	(mpd),				% N.B.O.
436     1918     341     316     0.25     0.03     0.017     0.13     4.09     46.00     40.00     1.49     98     99     91       251     1816     3.54     0.25     0.25     0.02     0.03     917     0.11     47.00     2.65     15.00     7.46     7.99     4.88     5.81     5.35     6.51     7.34     9.8     9.9     9.8     9.9     9.	Ð,	ဒ္ဓ	├~	2	SiO2	A1203	Na20		B203	Fe203	202	င္တ	<u> </u>	800°C 11	1000 000	)eviation	် ပိ	MgO	SiO2	B203	Total	CaO+MgO	
1.10   1.00   1.00   2.10	11.0	24.9		_	51.69		0.30	0.0		0.17			_	-	90.0	-7.49	53	86	171		328	44.14	%5.89
1.1.   1.1.	LTPI						0.25	0.05		0.17			_	_	39.10	-7.48	55	3	174		323	44.20	68.0%
18.66   18.66   18.66   18.66   19.60   19.6	LTP4			_	50.54	0.57	0.40	0.08	9.17	0.14			47.60		15.70	-7.46	5	4	214	129	463	39.09	62.1%
1.1.2   2.1.8   2.06   3.40   0.19   0.25   0.11   0.11   0.11   0.12   0.13	LTPS						0.31			0.17	0.15				38.80	-6.81	89	115	193		367	43.47	%1.89
11.25   27.59   32.6   57.20   0.13   0.15   0.16   0.17   0.16   0.16   0.17	LTP6				54.00	0.19	0.25			0.15			40.22	5.70	•	-6.53						40.35	64.9%
149   24.54   2.52   3.724   0.15   0.15   0.16   0.17   0.16   0.15	LTPL						0.13			0.17			39.36		5.26	-6.51	30	117	188		335	39.23	63.0%
10.37   27.8   3.29   58.18   2.44   0.15   0.15   0.16   0.16   0.16   0.25   0.16   0.15	LTP6				57.24	0.35	61.0			91.0			39.02	4.48		-5.51	8	8	119		210	39.53	62.3%
4.448     1.78     2.48     6.446     0.21     0.28     0.16     0.15     0.25     41.22     3.71     4.71     4.71     4.71     4.91     4.71     4.71     4.91     4.71     4.71     4.91     4.71     4.71     4.71     4.91     7.71     4.91     7.71     4.91     7.71     4.91     7.71     4.91     7.71     4.91     7.71     4.91     7.72     4.92     9.02     0.14     0.14     0.14     0.14     0.14     0.14     0.14     0.14     0.14     0.15     4.40     1.02     4.40     4.01     7.71     4.91     4.71     4.91     7.71     4.91     7.72     4.92     9.96     6.71     9.94     4.40     4.01     7.72     4.92     9.96     6.73     9.94     4.40     4.40     4.40     4.40     0.16     0.16     0.16     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40     4.40	LTP						0.15			0.16					15.50	-5.46	36	132	152		320	38.23	61.4%
11   1   1   1   1   1   1   1   1	LTP				_	0.21	0.28	0.05		91.0			42.28		19.10	-5.01	28	8	169		317	42.37	64.7%
1.8   1.2   1.39   51.59   0.26   0.40   0.06   0.11   0.21   0.40   0.12   0.41   0.21   0.41   0.22   0.41   0.22   0.41   0.22   0.41   0.22   0.41   0.22   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.42   0.43   0.45   0.42   0	LTP 4	24.0				0.31	0.26	0.05		0.15	0.25		41.52		4.71	4.73	\$6	8	180		331	41.83	64.3%
4.2.1     1.1.1     4.91     5.2.7     0.33     0.36     0.05     0.01     0.01     0.01     0.01     0.03     4.10     0.03     4.10     0.03     4.10     0.01     0.03     4.10     0.01     0.03     4.10     0.01     0.03     4.10     0.03     4.10     0.03     4.10     0.03     0.01	LTPI						0.42	90:0	-	0.17				49.10	•	¥.IS	79	26	200		355	44.11	66.1%
32.13     1.6.4     4.13     2.31     0.56     0.05     0.17     38.59     4.26     2.30     - 3.94     4.2     3.96     - 3.70     79     58       31.00     10.40     3.4     5.4.5     0.36     0.31     0.06     0.16     0.38     4.26     2.80     - 3.70     79     58       38.39     5.54     3.41     51.22     0.40     0.42     0.016     0.16     4.25     2.80     - 3.30     9.8     - 3.70     79     58       38.43     5.56     1.47     4.02     0.04     0.04     0.16     0.16     4.09     0.29     - 3.20     0.37     0.29     3.7     1.30     0.7     0.16     0.16     4.09     0.29     - 3.20     0.30     0.34     0.16     0.16     4.40     0.80     0.30     0.16     0.16     4.40     0.80     0.30     0.18     0.18     0.18     0.18     0.18     0.18     0.18     0.18     0.18     0.18     0.18     0	LTPS				52.72		0.30			0.14	0.21		41.04		\$39	3.96	65	106	161		362	41.40	64.1%
1100   1040   1412   44.50	LTPS				41.37	2.31	0.56	0.05		0.17				43.20	•	-3.94	42	4	179		262	42.60	69.3%
38.39     5.54     3.41     51.22     0.40     0.42     0.07     0.16     0.38     43.62     45.20     43.80     -3.37     83     32       34.38     9.46     14.72     0.05     0.04     0.015     0.16     0.38     -     -3.26     60     57       38.62     5.56     2.57     52.23     0.34     0.46     0.07     0.15     0.15     0.07     4.09     3.63     7.86     -2.89     2.9     3.7	LTPS				54.50	0.36	0.31	80.0	3.19	91.0				29.80		-3.70	92	58	200	8	367	41.40	62.0%
34.38     9.46     14.72     40.02     0.72     0.55     0.16     42.95     9.98     - 3.26     60     57       38.62     5.56     2.57     5.223     0.34     0.46     0.07     0.15     44.03     42.90     - 3.20     82     29       34.73     9.53     1.68     0.26     0.16     0.18     44.03     42.90     - 3.23     7.86     2.98     7.8     2.98     7.8     2.93     7.8     2.93     7.8     2.93     7.8     2.93     7.8     2.93     7.8     2.93     7.8     7.3     7	LIPI				51.22	0.40	0.42	0.07		0.16	0.38				13.80	-3.37	83	32	161		306	43.94	63.9%
38.62   5.56   2.57   5.2.23   0.34   0.46   0.07   0.15	LTPS				40.02	0.72	0.55			91.0		_		86.6	•	-3.26	9	57	8		313	43.84	70.5%
34.73     9.55     19.83     35.24     0.23     0.25     7.8     - 2.93     7.8     - 2.93     7.8     - 2.93     7.8     - 2.94     7.8     - 2.46     1.7     7.3     7.3     7.8     - 2.46     1.7     1.08       24.38     14.20     25.55     0.44     0.18     0.08     3.01     0.16     3.70     3.63     7.8     - 2.46     1.7     108       29.40     8.73     14.55     6.68     0.07     0.14     0.15	L'IP2				52.23	0.34	0.46	0.07		0.15		•		42.90	•	-3.20	82	53	199		310	44.18	63.7%
14.50   22.87   2.53   59.45   0.27   0.18   0.08   3.01   0.16   0.16   0.05   37.06   9.57   - 2.46   17   108   14.50   22.87   2.53   59.45   0.27   0.12   0.15   0	.TPS;	_			35.24	0.23	0.26			0.15			44.08	•	•	-2.93					0	44.28	73.0%
14.61   22.87   2.53   59.45   0.27   0.12   0.16   0.16   0.15   0.15   0.16   0.16   0.15	.TP7				57.52	4.0	0.18	0.08	3.01	0.18					7.86	-2.58	75	23	255	7	424	38.58	58.7%
29.40 8.73 14.55 46.68 0.07 0.44 0.13 0.15 38.43 - 3.23 0.13 13.44 0.13 13.64 14.01 1.62 4.67 0.09 0.70 0.05 0.15 0.15 13.64 10.25 0.13 12.46 9.86 14.02 4.67 0.09 0.70 0.05 0.15 0.15 13.64 10.25 0.13 12.40 11.52 4.90 54.88 2.06 0.28 0.05 0.07 0.26 138 0.25 0.07 0.26 13.0 13.07 3.61 0.24 82 0.95 11.01 1.62 56.65 1.38 0.29 0.07 0.26 13.8 13.07 3.61 0.24 13.61 0.24 13.61 0.24 13.61 0.24 13.61 0.25 11.01 1.62 56.65 1.38 0.29 0.07 0.16 0.13 13.07 3.61 0.24 13.61 0.24 13.61 0.24 13.61 0.24 13.61 0.24 13.61 0.24 13.61 0.24 13.61 0.25 0.15 0.15 0.15 0.15 0.15 0.15 0.15 0.1	LTP6			7	59.45	0.27	0.12			91.0				9.57	•	-2.46	17	108	83		208	37.48	58.4%
29.40     8.73     4.66     0.07     0.44     0.13     38.43     -     -     3.23     -     3.23     -     -     3.23     -     -     3.23     -     -     3.23     -     -     3.23     -     -     3.23     -     -     3.23     -										bove her	e combo	sitions h	ave devis	ntion of m	ore than	2.4wf%							
32.46     9.86     14.02     42.67     0.09     0.07     0.05     0.15     0.15     42.89     3.44     3.65     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.31     -1.32     -1.31     -1.32     -1.31     -1.02     72     74 <t< td=""><td>LTPS</td><td>_</td><td>⊢</td><td>14.55</td><td>46.68</td><td>0.0</td><td>0.44</td><td></td><td></td><td>0.13</td><td></td><td></td><td>38.43</td><td>-</td><td>•</td><td>3.23</td><td></td><td></td><td></td><td></td><td></td><td>38.13</td><td>90.1%</td></t<>	LTPS	_	⊢	14.55	46.68	0.0	0.44			0.13			38.43	-	•	3.23						38.13	90.1%
31.46     9.58     12.64     44.91     0.69     0.54     0.05     0.14     Above bere compositions have P2O3 content more than 12.5%%     - 0.45     - 0.45     - 0.45     - 0.45       24.93     11.52     4.90     54.88     2.06     0.28     0.03     0.07     0.26     37.33     3.07     3.61     - 0.45     72     74       28.72     11.01     1.62     56.65     1.38     0.29     0.07     0.26     37.33     3.07     3.61     0.24     82     69       36.89     5.70     5.05     1.38     0.29     0.07     0.26     0.13     3.07     3.61     0.24     82     69       30.93     11.01     4.50     5.03     0.43     0.05     0.15     0.15     0.25     41.83     3.24     3.24     3.24     3.2     1.65     69       30.93     11.01     4.50     0.45     0.05     0.15     0.15     0.25     41.83     3.24     3.26     1.65     71     42 <td>LTP6</td> <td></td> <td></td> <td></td> <td>42.67</td> <td>0.09</td> <td>0.70</td> <td>0.05</td> <td></td> <td>0.15</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>-1.31</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>42.32</td> <td>67.4%</td>	LTP6				42.67	0.09	0.70	0.05		0.15						-1.31						42.32	67.4%
24.93     11.52     4.90     54.88     2.06     0.28     0.05     1.38     Above bare compositions have P2O5 content more than 12.5%*%     72     74       28.72     11.01     1.62     56.65     1.38     0.09     0.07     0.26     37.66     32.10     -     1.02     72     74       36.89     5.70     5.05     1.38     0.29     0.07     0.26     37.33     3.07     3.61     0.24     82     69       30.93     11.01     4.90     5.05     0.30     0.43     0.10     0.16     0.13     42.50     3.41     5.03     -1.65     88     35       30.93     11.01     4.90     51.96     0.30     0.45     0.05     0.15     0.15     0.25     41.85     3.24     3.92     -1.65     71     42       30.93     11.01     4.90     0.53     0.05     0.15     0.15     0.15     0.15     42.90     2.62     2.78     7.65     57     42       30.34	LTP61	3.1	-	12.64	14.91	0.69	0.54	0.00		0.14			40.25	-		0.45						41.04	64.8%
24.93     11.52     4.90     54.88     2.06     0.28     0.05     1.38     32.66     32.10     -     1.02     72     74       28.72     11.01     1.62     56.65     1.38     0.29     0.07     0.26     37.33     30.70     3.61     0.24     82     69       36.89     5.70     5.05     51.22     0.31     0.43     0.10     0.16     0.13     42.50     3.41     5.03     -1.72     88     35       30.93     11.01     4.90     51.96     0.30     0.43     0.05     0.15     0.13     42.50     3.41     5.03     -1.65     88     35       30.93     11.01     4.90     51.26     0.30     0.45     0.05     0.15     0.15     40.89     1.25     1.65     78     42       30.93     30.74     30.65     0.65     0.65     0.17     40.89     1.72     1.95     1.65     71     83       30.34     9.84     9.86									At	ove bere	composi	tions hav	e P205	content m	nore than	12.5wt%							
28.72     11.01     1.62     56.65     1.38     0.29     0.07     0.26     37.33     3.07     3.61     -0.24     82     69       36.89     5.70     5.05     51.22     0.31     0.43     0.10     0.16     0.13     42.50     3.41     5.03     -1.72     88     35       30.93     11.01     4.90     51.96     0.30     0.45     0.05     0.15     0.25     41.85     3.41     5.03     -1.65     88     35       32.93     9.77     12.01     44.34     0.19     0.45     0.05     0.15     0.25     41.85     3.24     3.92     -1.65     78     69       32.53     9.47     9.65     46.79     0.85     0.05     0.17     40.88     1.72     1.95     -1.65     71     83       29.34     9.84     9.86     50.26     0.15     0.05     0.15     0.95     0.95     0.95     1.84     71     83       29.34     9.84	LTPS;	_	$\overline{}$		54.88	2.06	0.28	0.05		1.38				32.10	•	1.02	22	7	<del>3</del>		286	36.45	\$6.1%
36.89     5.70     5.05     51.22     0.31     0.43     0.10     0.16     0.13     42.50     3.41     5.03     -1.72     88     35       30.93     11.01     4.90     51.96     0.30     0.45     0.05     0.15     0.25     41.85     3.24     3.92     -1.65     78     69       32.53     9.47     12.01     44.34     0.19     0.45     0.05     0.15     0.25     41.85     3.24     3.92     -1.65     78     69       32.58     9.47     9.65     46.79     0.65     0.05     0.19     0.19     40.88     1.72     1.95     -1.65     57     42       29.34     9.65     46.79     0.65     0.05     0.17     0.65     0.05     0.17     40.88     1.72     1.95     -1.56     71     83       29.34     9.84     9.88     50.26     0.15     0.65     0.05     0.15     0.05     39.45     0.01     1.84     71     83	LTPS	28	-	-	\$6.65	1.38	82.0	600		92,0	$\dashv$	7	37.33	-	-	-0.24	82	69	129		310	39.73	58.4%
36.89     5.70     5.05     51.22     0.31     0.43     0.10     0.16     0.13     42.50     3.41     5.03     -1.72     88     35       30.93     11.01     4.90     51.56     0.30     0.45     0.05     0.15     0.25     41.85     3.24     3.92     -1.65     78     69       32.39     9.77     12.01     44.34     0.19     0.53     0.05     0.19     2.62     2.78     -1.65     57     42       32.58     9.47     9.65     46.79     0.65     0.01     40.88     1.72     1.95     -1.65     57     42       29.34     9.84     9.64     0.05     0.17     0.05     0.15     0.05     39.45     0.01     1.95     -1.56     71     83       29.34     9.84     9.84     0.46     0.05     0.05     0.05     0.05     0.05     1.84     71     83								į		Abov	o here fil	rres have	A1203	content a	-1	ئۇ	İ						
30.93 11.01 4.90 51.96 0.30 0.45 0.05 0.015 0.25 41.85 3.24 3.92 -1.65 78 69 89 81.25 11.01 4.34 0.19 0.45 0.05 0.05 0.19 40.89 1.72 1.95 1.65 71 54 22 29.34 9.85 50.26 0.17 0.56 0.05 0.05 0.15 0.05 0.05 0.05 0.05 0.05	LTPI				51.22	0.31	0.43	0.10		91.0	0.13				5.03	-1.72	88	35	204		327	42.59	62.2%
32.93 9.77 12.01 44.34 0.19 0.53 0.05 0.05 0.19 42.90 2.62 2.78 -1.65 57 42 42 42.80 9.47 9.65 46.79 0.84 0.46 0.05 0.17 0.18 0.05 0.17 0.05 0.15 0.05 0.15 0.05 0.01 0.00 1.84 71 83 42 42 40.88 0.47 0.88 0.17 0.184 71 83 42 40.88 0.184 0.184 71 83 43 43 43 8.88 8.88 8.88 8.88 8.88 8.	LTPL				51.96	0.30	0.45	0.05		0.15	0.25				3.92	-1.65	78	69	161		338	41.95	63.0%
32.58 9.47 9.65 46.79 0.84 0.46 0.05 0.17 0.15 0.05 1.05 0.05 1.84 1.72 1.95 1.95 1.95 1.95 1.95 1.95 1.95 1.95	LTPS			12.01	44.34	0.19	0.53	0.03		0.19					2.78	-1.65	52	7	223		322	42.70	67.0%
29.34 9.84 9.58 50.26 0.17 0.56 0.05 0.15 0.05 39.45 0.01 0.00 1.84 71 83 Above bere SiO2 content less than 52wt%	LTPS			9.65	46.79	28.	9.46	503		0.17					<u>z</u> .	-1.56	77	X	28		328	42.05	63.1%
Above here SiO2 content less than \$2wt%	LTPS			9.58	50.26	0.17	0.56	gg Sg	7		0.05	$\exists$	39.45	0.01	8	<u>z</u>	7	8	222		376	39.18	60.1%
											Above be	re SiO2	content	ess than	Szwr%								

TABLE II (Part 2)

_		Ç.	<u> </u>		•	٥٠		Т	1.0		.6	.0	7																	,_
% N.B.O.			62.6%	_	62.6%	60.3%	\$1.7%		61.0%	59.7%	60.2%	58.8%	%0.09	\$4.9%	57.5%	58.7%	58.8%	\$6.1%	56.3%	\$2.6%	58.2%	55.4%	54.5%	29.0%	56.5%	58.0%	55.2%	\$4.0%	55.5%	
	CaO+MgO	39.58	42.40	39.45	42.27	42.20	38.75		39.78	39.22	38.85	42.38	40.84	38.96	41.36	38.94	40.19	40.16	38.54	37.55	40.12	39.56	38.42	40.28	36.73	40.25	39.08	38.25	38.24	
	Total	-	356	316	361	300	337		359	319	366	292	361	\$	292	327	327	275	334	382	344	292	167	582	378	315	787	312	288	
	B203				-								20	35			12	13	7	\$	22	6	22				91		_	
(mdd	┝	╘	200	167	207	208	205		161	197	226	506	7	278	506	175	187	195	184	26	192	175	194	172	741	188	203	193	173	
Solubility (ppm)	MRO	┢	7	8	22	34	\$		흝	9/	68	<u> </u>	3	7	11	&	8	30	4	~	65	32	32	25	<b>28</b>	21	33	82	8	
Ø	CaO	<u></u>	88	8	83	88	3		38	46	51	9/	22	73	72	ß	62	37	26	26	25.	8	\$	8	49	92	32	16	67	
	L	┺	=		20		- 2		61			99		<u>.</u>		_	~		٠,	_	- 7	<u></u>				_	_			
Shrbnkage	1000°C Deviation	0 -2.0	0 -2.01	5 -1.93	0 -1.79	0 -1.27	2.02	1 55 WF%	1 -2.29	-2.05	-1.92	-1.68	-1.52	-1.49	-0.53	-0.49	-0.12	-0.08	90.0	9.0	-0.02	0.66	0.71	0.76	0.81	6.9	-1.8	2.68	2.99	\$8wf%
Shrt		+-	8 29.70	3.05	30.10	35.50	4 1.53	Above here SiO2 content 52wt% to less than 55wt%	7 2.14	1 3.73	0 4.16	٠,	232	1.43	1.04	1.77	1.84	2.13	2.83	3.00	1.81	6.1	239	2.76	89:	1.79	1.93	1.40	1.16	Above here SiO2 content 55 wt% to less than 58 wt%
		7 23.30	3 3.38	7 2.24	2.55	7	0 1.24	2wt% to	2 1.97	3.01	3.8	3 45.85	5 1.20	9 0.59	6 1.74	131	3 0.9	1.57	1.68	1.23	1.02	1.07	1.15	1.89	27	<u></u>	1.47	1.22	6.3	wt% to
<b>Z</b>		39.37	42.13	38.77	42.00	41.95	38.10	outent 5	39.52	39.04	38.49	42.03	42.55	41.69	\$.6	38.74	41.13	40.99	40.92	40.43	41.06	40.26	40.00	40.23	36.34	40.13	39.98	38.02	38.21	stent 55
	ပွ							SiO2 a								0.05														SiO2 con
	202	_		0.58			0.18	ove hare				0.17																0.02		ve here
cent)	Fe203	1	0.16	0.16	0.15	0.15	0.15	₽.	0.10	0.14	0.14	0.19	0.16	0.14	0.21	0.14	0.15	0.15	0.18	0.13	0.15	0.15	0.15	0.15	0.13	0.15	0.14	0.14	0.14	Abo
Weight percent)	B203	_											<b>8</b> .	3.54			1.1		2.69	3.54	1.08	0.94	1.95				1.06			
• 1	K20		90.0		9.0	0.07	0.05		0.05			0.12	0.07	0.09	0.10	0.0	0.0	0.09	0.0	0.0	0.0	0.08	0.08	0.05		0.02	0.08	0.0	0.05	
ton (X		0.29		0.24		0.46	<u>8</u>		0.31	0.26	0.24	0.39	0.30	0.20	0.41	0.22	0.32	0.31	0.23	0.23	0.33	0.30	0.31	0.32	0.23	2	2	9.63	0.36	
Compos	A1203	0.25	0.32			0.39	0.52		0.31	0.22	0.30	0.43		0.55	0.45		0.28		0.32	_	0.27	0.31	0.38	0.21	0.31	0.25	0.27	0.36	0.22	
Chemical Composition (XRF	-	-			53.52	54.19	52.24		55.45	57.63	55.92	55.09		56.51	\$5.25		56.19	57.92	57.95	57.96	57.13	57.84	57.85	\$5.65	57.93	57.30	\$7.39	% %	57.32	
<u>ت</u>	4	92.9		4.87	3.36	2.54	7.78		4.00	2.52	4.55	1.23	0.85			3.33	1.68				98.	0.82	98.0	3.34	4.66	1.68	1.67	3.73	3.66	
	_	L.	11.35		11.35	5.58	6.83		17.48	18.41	18.77	2.09		0.65	1.96	15.66	9.68	4.77	8.53	0.62	9.56	4.73	4.75	10.45	17.56	9.81	4.73	38.	9.33	
	ဝ	22.89	31.05			36.62	31.90		22.30	20.81	20.08	40.29		38.31				35.40		-		34.82		29.83	19.17	30.4	34.35	33.69	28.91	
<b>ğ</b>	I.TP	[183	1.TP20	LTP 2	1.TP12	1.TP21	1.TP48		LTP47	L.TP64	LTP68	LTP29	I.TP41	LTP71	LTP30	LTP1	L.TP43	LTP37	L.TP32	1.1773	LTP42	LTP38	LTP40	LTP 6	I.TP69	LTP34	LTP39	1.TP26	1.1777	

30			ŧ	Chemical Commodition (VDF	Journal of	Hom CVD	T.M.	1	1		Γ											
			1			4	F	- אכנינוון אבוננטון	chit			2	<b>9</b> 7	Shrinkage	بو		Solubility (nom)	(moun)				Q 14 %
LTP	ဒ္ဓ	S S	P205	_	SiO2   AI2O3   Na2O	Na2O	20	B203	Fe203	202	Ş	_	SONOT 1	10000	10000 D	3			F	т		% R.B.O.
A TPKK	16.66	71.15		⊢	3	:		-				1	=1	3	CVIBILOD	3	Σ Σ	SIOZ	B203	<u>ਭ</u>		
3	3	01:17	ĵ	<u> </u>	67.0	C. 23			0.13			36.58	2.65	3.19	-1.03	S	78	140		Ş	3,0	
LTP65	20.36	17.74	2.50	58.75	92.0	0 33	_		613				-		1 :	3	5	-	_	3	30.51	57.7%
T	, ,				}				3			3/./5	87.7	75.7	-0.62	4	33	₹ 2		767	38.10	27.6%
7717		_		59.64	0.37	0.27	90.0	3.25	0.14	_		39.11	3.37	91.9	-0.16	6	35	8	- 2	376	26 20	
LTP35	32.72	4.76		58.60	0.28	0.31	0.08	3 00	0.15	_	_	40 40	37	300	9,0	: 8	? ;		3	676	77.00	25.0%
I TD21		0, 0		60,30					3		_	<u>}</u>	<u>.</u>	2.63	9	20	97	62	52	322	37.48	53.5%
				28.70	97.0	2	8	3.00	0.18			8 8	3.15	4.88	0.70	5	3	202	3	387	27 50	.01 33
L.TP36	33.37	<del>2</del>		\$8.90	0.27	0.30	0.08	2.10	0.15			40.13	5	3.13	8	ç	22	2	; ;		2	
L.TP33	30.20	9.03		59.01	0.27	0.08	9	8					_		2	ì	3	<b>8</b> 61	3	293	38.19	\$3.9%
TOTI		8					3	Ŗ	3			40.07	91.7	2.74	 5	88	S	193	2	353	39.23	\$6.1%
¥		8		18.65	0.35	0.36	0.0	3.16	0.13		0.19	38.82	39.	2.71	1.81	<b>&amp;</b>	7	103	3	360	26 03	è
LTP45	24.10	11.40		62.48	0.5	0.24	90.0	1.04	0.15	_		36 76	- 41	2 16	9,	ě	: ;	? ?	; ;	9	25.55	24.1%
1.TP46 28 43	28 43	£ 2	3 40	AC 08	5	;							_		9,5	5	2	26	2	5	35.50	51.3%
			_	37.43	6.63	3	8	1	0.13	1	7	37.06	<u>6.9</u>	0.99	3.93	71	\$	175		192	37.25	53.3%
										Above b	are SiO2	content	Above here SiO2 content 58wt% or more	f more					-			